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Prototype Design of Electronics Laboratory Door Security for PTE Department Using Arduino Nano Based E-KTP

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Abstract

The electronics laboratory of the PTE department still faces issues with conventional keys, limiting access control. To address this, a prototype door security system using e-KTP as an access key was developed through a quantitative experimental method. A system trial was carried out to evaluate the performance of the solenoid and LCD components. Seven e-KTP samples were selected using random probability sampling. The system was built using an ATmega328 microcontroller on an Arduino Nano, with RFID as input and LCD and solenoid as outputs. An admin card was designated to manage user access, including registration and deletion. Testing results revealed an authentication success rate of 87.5%. The distance and response time of RFID reading showed 85.71% accuracy, with a response time of under 2 seconds and a maximum effective scanning distance of 2.5 cm. Additionally, metal was identified as the main obstacle to RFID signal transmission, with a success rate of 83.33% when tested with barrier materials. These results demonstrate the effectiveness and feasibility of the e-KTP-based door security prototype for the PTE electronics laboratory.

Keywords*: Door Lock, Prototype, E-KTP, Experimental Method*

Abstrak

Penggunaan kunci konvensional di laboratorium elektronika Prodi PTE masih menghadapi kesulitan sehingga akses masuk menjadi terbatas. Sebuah prototipe pengaman pintu berbasis e-KTP untuk akses laboratorium dikembangkan menggunakan metode eksperimen kuantitatif. Uji coba sistem dilakukan untuk mengetahui kinerja solenoid dan LCD yang dihasilkan. Sampel terdiri dari 7 KTP yang diambil menggunakan teknik probability sampling secara acak. Prototipe pengaman pintu laboratorium elektronika menggunakan e-KTP dirancang menggunakan mikrokontroler At-mega328 dalam Arduino Nano, dengan RFID sebagai input serta LCD dan solenoid sebagai output. Kartu admin menjadi e-KTP utama untuk proses pendaftaran dan penghapusan hak akses pada laboratorium. Hasil pengujian menunjukkan tingkat keberhasilan otentikasi sebesar 87,5%, dan keberhasilan pengujian jarak serta waktu respon pembacaan RFID terhadap e-KTP sebesar 85,71%, dengan waktu respon kurang dari 2 detik dan jarak maksimal untuk scan e-KTP adalah 2,5 cm. Tingkat keberhasilan pengujian material penghalang dan waktu pembacaan RFID terhadap e-KTP adalah 83,33%, dengan logam sebagai material yang mengganggu proses pembacaan RFID terhadap e-KTP. Hal ini menunjukkan bahwa prototipe pengaman pintu laboratorium elektronika Prodi PTE bekerja dengan baik.

Kata Kunci: Pengaman Pintu, Prototipe, E-KTP, Metode Eksperimen

Introduction

The development of technology towards the need for a reliable and efficient laboratory space security system, especially in academic environments, is important to ensure limited access only to authorized parties. Every human being wants a conducive security situation, so many ways are done to ensure room security [1]. Door security is an important aspect and is becoming increasingly sophisticated with the help of technology in every building [2]. By applying technology, security systems can reduce the crime rate that occurs in society, especially theft in the campus environment [3]. Traditional mechanical key security systems have limitations because they only provide one layer of security, which is vulnerable to theft and duplication [4]. Based on previous research with the title "Room Security System Application Using E-KTP". The result of the tool assembly is a miniature house that has a door that has been installed, Solenoid, LCD, and RFID sensor [5]. This Radio Frequency Sensor consists of two main components: transceiver (reader) and transponder (tag). Radio Frequency Identification (RFID) technology and keypads are two key components in modern security systems [6]. The reader is usually connected to a microcontroller that functions to process data obtained from the reader [7]. Based on the explanation, the author is interested in designing a room security system application using e-KTP to minimize the possibility of unwanted things happening.

Literature Review

a. Door Safety Prototype

The prototype of the laboratory door safety in this study will be made with a miniature laboratory room which is used as a substitute for a real laboratory. A laboratory is a room equipped with equipment, instruments, and arrangements that enable scientists, researchers, or students to conduct scientific observations, measurements, and experiments [8]. A prototype is a system or design which is an example or standard of the object to be worked on [9]. The creation of this prototype is made for simulation to make it easier to get the desired results so that it can obtain an image that is used regarding the security of the PTE study program electronics laboratory door [10]. This electronic laboratory door safety prototype. This laboratory door safety prototype miniature is made from cardboard x3, has dimensions of 25 cm long, 20 cm wide, and 15 cm high. The door is in front which will be used for the door lock demonstration.

b. Door Security Using e-KTP

KTP based on Population Identification Number or referred to as e-KTP uses a smart card. e-KTP refers to the ISO 14443 A/B standard, works well in a temperature range between -25˚C to 70˚C and with an operational frequency range of 13.56 MHz ± 7 KHz. e-KTP has a SAM (secure access module) in the form of 4 bytes UIDs (Unique identifier) in a range of 10-digit combinations [11]. In making door security using this e-KTP, an Arduino nano system is used which is integrated with RFID which has an LCD output as a display during the process. Scanning and solenoid as a door lock. The use of RFID as a Scanner to read the UID on e-KTP which utilizes radio waves during the scanning process [12]. The components used in making this laboratory door security are various, here are the components and their explanations in making laboratory door security.

1. RFID (*Radio Frequency Identification*)

Figure 1. RFID RC 522

RFID has a chip that can store data in the form of an ID number and functions to transmit data to the RFID reader via radio waves emitted by the reader [13]. An IT infrastructure that enables application development and offers RFID device and data administration is necessary due to the widespread use of radio frequency identification (RFID) systems in application domains [14]. The antenna on the RFID tag (tag antenna) and the RFID reader (reader antenna or interrogator) function to transmit data from the RFID tag chip to the RFID reader via radio waves. For HF (13.56Mhz) there are many tags available, for example RFID RC522 MIFARE. The reading distance is limited, but the available memory is much higher. Starting from 384 bits, up to 8 kbit. The additional components in this prototype design such as Solenoid which functions as a door lock, Relay module functions as an electric switch that can work automatically according to the given logic command., also LCD or Liquid Crystal Display is a type of display media that uses liquid crystals to produce visible images.

The system's capacity to handle data efficiently is tested in order to determine the RFID card reading speed [15]. This technology is widely used in various products such as laptop screens, cellphones, calculators, digital watches, multimeters, computer monitors, televisions, portable gaming devices, digital thermometers, and other electronic products[16]. Basically, this component technology are an important component in the development of modern technology used in various electronic devices[17].

Method

This research is experimental quantitative research. The focus of quantitative research methods is on gathering and evaluating structured data that can be quantitatively represented and dependable measures that enable statistical analysis[18]. This experiment was conducted by designing a door safety prototype that was applied to the electronics laboratory of the PTE department. By conducting experiments to design and manufacture devices, it is expected to get good test results. Experimental research is conducted to establish cause and effect relationships between variables, by involving the manipulation of independent variables to observe their effects on dependent variables [19].

a. Research Design

The research was conducted with several related stages. The research stages start from the planning stage which aims to determine the problem being studied, formulate the problem, determine the research objectives, and literature study which aims to find relevant theories. The next stage is the needs analysis stage that will be used in system design. Next is the design stage which includes the stages of system diagram design, hardware design, and software design. Then the next stage is the implementation stage by implementing the system that has been designed into the miniature electronics laboratory of the PTE Study Program that has been made. Continued with the testing stage which ends with the results analysis stage.

1. **Planning Stage**

To begin, problem identification is carried out based on the current conditions and supplemented with relevant secondary data. The next stage is problem formulation, where the author creates questions that will be answered through this research based on existing phenomena. Determination of objectives is carried out to clarify what is to be achieved in this research related to the problem being studied. Literature study is the stage of searching, collecting, and analyzing data related to problems from various sources, both government statistical data and official sites related to the topic of the problem, as well as reviewing several related journals to differentiate previous research with the research to be carried out.

2. **Needs Analysis Stage**

RFID as an Input sensor for UID from E-KTP, components that will work as output that has been set according to the system to be created, namely LCD, Buzzer, and Solenoid. Solenoid as the main output in this system, which will work to lock the door. When the RFID Tag is read by the RFID Reader, the Arduino UNO will send a message to the Solenoid Door Lock and will open the lock after the Reader matches the unique key [20].

3. **Implementation**

The implementation stage is the stage where the door security device components are assembled and then implemented in the miniature electronics laboratory of the PTE Study Program. The following is a display of the prototype from above in Figure 2.

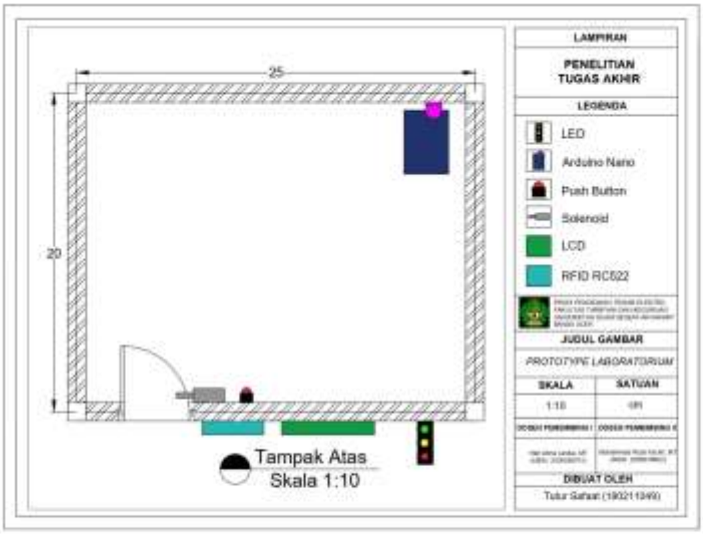

Figure 2. Top view

4. **System Testing**

The testing stage is carried out after the implementation stage, this stage explains several tests carried out in this study. Some of the tests carried out are; Authentication success test, Testing the response time and distance of RFID reading on e-KTP, Testing the barrier material and RFID reading time on e-KTP.

5. Analysis of Results

The data variables needed in the data collection process to evaluate the performance of the tool are the number of e-KTPs successfully registered using the admin card. The prototype's ability to read the distance and time of reading RFID on e-KTP. The prototype's ability to read when covered by barrier material.

b. Population and Sample

The population used ID cards from 8 lecturers and 302 PTE students. The sample used in this study consisted of 7 e-ID cards. The sample was obtained using probability sampling techniques, which in this case were e-ID cards from laboratory assistants. The model used was simple random sampling (simple random or random numbers) from a total of 302 e-ID cards of lecturers and students.

c. Data Collection Instruments

The quantitative experimental research data collection instrument for this study was carried out using an observation sheet, which contained several stages of design questions and several trials.

d. Data Collection Techniques

Data collection techniques are carried out using the observation, documentation and measurement methods which aim to answer existing problems. The following data collection techniques are carried out with observation sheets.

e. Data Analysis

1. Prototype Functionality

To measure the results of prototype design, a measurement scale is needed that contains aspects of the observation measurement assessment of the prototype design results. The observation measurement scale can be seen in Table 1.

Table 1. Observation Measurement Scale

Scale	Observation Measurement
1	Very Bad
2	Bad
3	Sufficient
4	Good
5	Very Good

The percentage success criteria that will be measured in the prototype testing results. To calculate the number of successes from the prototype design results, Equation… 1 is used.

$$R = \frac{NT}{JP} \quad \text{..1)}$$

R = Mean
NT = Total Success
JP = Number of Attempts

2. Prototype Testing Results

The following are the success percentage criteria in table 2.

Table 2. Percentage of Success

No	Percentage of Success	Success Rate
1	80% - 100%	Very Good
2	60% - 79%	Good
3	40% - 59%	Sufficient
4	20% - 39%	Bad
5	1% - 19%	Very Bad

The percentage success criteria that will be measured in the prototype testing results are; Authentication success, Testing the distance and time of reading RFID on e-KTP and Testing RFID readings if there is obstruction material. To calculate the percentage of success from the prototype testing results, Equation 2 is used.

$$Percentage\ of\ success = \frac{TK}{JP} \times 100\% \qquad \text{........2)}$$

TK = Total Success
JP = Number of Trials

Result and Discussion

a. Door Safety Prototype Design Results

Trial process of E-KTP Registration using Admin card. This process requires one e-KTP as an Admin that functions for registration and deletion. This test was conducted with 7 e-KTPs with several repeated trials, here is the appearance of the tool when conducting several tests:

Figure 3. Access Accepted View

The image above is a display on the prototype if the e-KTP has been registered and saved to the EEPROM, with the LCD displaying the words "Access Accepted, Door Open" and the green LED lights up as a sign that access was successful and the door will open. When the e-KTP is not registered, access will be denied and the LCD Prototype will display "Access Denied Not Registered" the door will remain locked, as can be seen in Figure 4.

Figure 4. Access Denied Display

Observational assessment of the results of the door safety prototype design are as below. From the Table 3, shows the observation results of the prototype design, indicating that the design is highly suitable for the intended needs (score: 5), although improvements are needed in aesthetics and safety (score: 3).

Table 3. Observation of Prototype Design

No	Design	Observation (1-5)
1	Suitability of design to needs	5
2	Design aesthetics and safety	3

b. Prototype Functionality Observation

By using Equation 1, the average number of successes obtained from the observation results in Table 4. Table 4 presents the observation results on the prototype's functionality, showing consistent performance across all aspects—e-KTP registration/ deletion, security system, and ease of use—with each receiving a score of 4 out of 5.

Table 4. Prototype Functionality Observation

No	Function	Observation (1-5)
1	Registration/deletion of e-KTP	4
2	Security System	4
3	Ease of Use	4

Using Equation 1, the average number of successes obtained from the observation results in table 4 is 4, so according to Table 1 the average number of successes of 4 is (Good). The registered E-KTP will automatically be able to access the door by tapping on the RFID. When access is approved or successful, the screen that appears is as follows.

Figure 5. Display When Access is Accepted

When the e-KTP is not registered, access will be denied and the LCD Prototype will display "Access Denied Not Registered" and the door will remain locked, as can be seen in Figure 6.

Figure 6. Display When Access is Denied

For Registration and Deletion of e-KTP on the LCD prototype will display "Access/Add/Remove" as a sign of registration or deletion to be carried out, and the Yellow LED will light up, and confirmed using the Admin Card. The display on the prototype when registering/deleting e-KTP can be seen in Figure 7.

Figure 7. Display During the Registration/Deletion Process

For the display on the serial monitor during the e-KTP registration process:
Scanned KEY'S UID :

43E1D5A // UID e-KTP Admin (First tap)
Scanned KEY'S UID :
41E7922 // UID e-KTP register
Scanned KEY'S UID :
43E1D5A // UID e-KTP Admin (Tap Confirm)
Succesfully added ID record to DATABASE
Scanned KEY'S UID :
41E7922 // UID e-KTP Register has access
Welcome, Access successful

Display on the serial monitor during the process of deleting the ID from the e-KTP:
Scanned KEY'S UID :
43E1D5A // UID e-KTP Admin (First tap)
Scanned KEY'S UID :
5876918 // UID e-ktp Remove
Scanned KEY'S UID :
43E1D5A // UID e-KTP Admin (Tap Confirm)
Successfully removed ID record from DATABASE

c. Door Safety Prototype Test Results

Testing for authentication success was carried out with 8 attempts using an e-KTP that had been registered using an Admin card.

Table 5. ID of the e-KTP used

Test	ID	Success (Yes/No)
1	43E1D5A	Yes
2	5876918	Yes
3	41E7922	Yes
4	448544A	Yes
5	49499A	Yes
6	F9CE2BB	Yes
7	2C63D61	Yes
8	89B9E2BA	Yes

By using Equation 2, the percentage of success obtained from the observation results in table 5 is 87.5%. Thus, according to Table 2 the percentage of success of 87.5% is (Very Good). Display on Serial monitor when reading RFID on e-KTP during Authentication process.
Scanned KEY'S UID :
43E1D5A // UID e-KTP Admin
Scanned KEY'S UID :
5876918 // UID e-KTP 1
Welcome, Access successful
Scanned KEY'S UID :
41E7922 // UID e-KTP 2
Welcome, Access successful
Scanned KEY'S UID :
448544A // UID e-KTP 3
Welcome, Access successful

Scanned KEY'S UID :
49499A // UID e-KTP 4
Welcome, Access successful
Scanned KEY'S UID :
F9CE2BB // UID e-KTP 5
Welcome, Access successful
Scanned KEY'S UID :
2C63D61 // UID e-KTP 6
Welcome, Access successful
Scanned KEY'S UID :
89B9E2BA // UID e-KTP 7
Welcome, Access successful

d. Testing the distance and time of reading RFID on e-KTP

This test was carried out to determine the reliability of the prototype in determining the maximum distance of the scanning process between e-KTP and RFID.

Table 6. Testing the Distance and Time of Reading RFID on e-KTP

Trial Test	Testing Distance	Time (Seconds)	Conclusion
1	0 cm	0,66	Succeed
2	0.5 cm	0,73	Succeed
3	1 cm	0,99	Succeed
4	1.5 cm	1,12	Succeed
5	2 cm	1,23	Succeed
6	2.5 cm	1,44	Succeed
7	3 cm	-	Not successful

By using Equation 2, the percentage of success obtained from the observation results in table 6 is 85.71% (Very Good).

e. RFID Scan Testing if There is Obstruction Material

To determine the effectiveness of RFID signal reading in non-ideal conditions, tests were carried out with various types of materials that function as barriers between the RFID tag and the reader. By using Equation 2, the percentage of success obtained from the observation results in table 7 is 83.33% (in category Good). The trial testing is shown at the Table 7 below.

Table 7. RFID Scan Test Whether There Is Blockage Material

Trial Test	Barrier Material	Duration (Seconds)	Description
1	Paper	0,77	Succeed
2	Wood	0,92	Succeed
3	Plastic	0,75	Succeed
4	Cloth	0,87	Succeed
5	Iron	1,02	Succeed
6	metal	-	Not successful

Based on the data, the average success rate obtained from observations on the results of the door security prototype design is calculated using Equation 1. The average number of successes in the door security prototype design obtained from the calculation results in table 3 is 4 (good), and for the average number of successes obtained from the calculation in table 4 is an average success of 4 (good). The percentage of success in the authentication success test obtained is 87.5% (Very Good), The percentage of success in testing the distance and response time of RFID reading on e-KTP was 85.71% (Very Good), and the percentage of success for testing the barrier material and RFID reading time on e-KTP was 83.33% (Good).

Conclusion

This prototype works as a door security in the electronics laboratory of the PTE study program. The admin's e-KTP is the main key for the registration process and removing access rights, thus facilitating the process of transferring/changing access rights. The success rate of the door security prototype design for the prototype design indicator and prototype functionality which got an average success rate of 4 (good).

The results of the laboratory door security prototype test showed that the device operated very well. The authentication success rate reached 87.5%, with the success of the distance test and the response time of RFID reading on e-KTP reaching 85.71%. The response time for reading RFID on e-KTP was less than 2 seconds, and the maximum distance for scanning e-KTP was 2.5 cm. The percentage of success of the barrier material test and the RFID reading time on e-KTP was 83.33%, with metal as a material that can interfere with the RFID reading process on e-KTP if covered.

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